63-3-2

Third Quarterly

Progress Report

PRODUCTION ENGINEERING MEASURE
for
VOLTAGE-TUNABLE MAGNETRONS

Covering the period

19 October 1962 through 18 January 1963

Contract No. DA-36-039-SC-86722

U.S. ARMY ELECTRONICS MATERIEL AGENCY
225 South Eighteenth Street
Philadelphia 3, Pennsylvania

GENERAL ELECTRIC COMPANY
POWER TUBE DEPARTMENT
Schenectady, New York

PRODUCTION ENGINEERING MEASURE
for
VOLTAGE-TUNABLE MAGNETRONS

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Object: To conduct a program for a Production Engineering Measure in accordance with Step I of Signal Corps Industrial Preparedness Requirements No. 15 for Voltage-Tunable Magnetron Types Z-5364 and ZM-6001.

Signal Corps Contract No. DA-36-039-SC-86722
Order No. 19044-PP-62-81-81

Prepared by

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TABLE OF CONTENTS

ABSTRACT

A significant improvement in performance of the low-frequency package has been achieved. Progress with respect to noise performance of both packages is reported. The problem of inconsistent vibration performance is better understood and work is proceeding to improve this performance. Preliminary electrical data indicates that the hydrogen-brazed version is comparable to the vacuum-brazed tube. The low-frequency package has been redesigned to increase the center frequency about 150 megacycles. Eleven electrical samples were delivered during this reporting period and the chief problems with these are discussed. The analysis of processed electrical-discharge machined anodes is presented.

PURPOSE

The purpose of this contract is to conduct a program for a Production Engineering Measure (PEM) in accordance with Step I of Signal Corps Industrial Preparedness Procurement Requirements No. 15 for Voltage-Tunable Magnetron Types Z-5364 and ZM-6001.

This PEM program, a joint effort of the General Electric Power Tube Department's Engineering and Manufacturing Sections, consists of three phases:

Phase I - Engineering and Manufacturing Phase
(Delivery of 14 each engineering samples)

Phase II - Establishment of Production Line
(Delivery of four each preproduction samples)

Phase III - Production Run
(Delivery of 50 each production packages)

NARRATIVE AND DATA

ENGINEERING

Deliveries

As a result of the control-electrode redesign to increase saturation current, the new delivery date for the first ten engineering samples (five of each type) was changed from October 18, 1962 to December 14, 1962. The second delivery date has been changed from January 18, 1963 to February 18, 1963. Subsequent deliveries will be according to the original dates; therefore, no time extension will be required for the over-all Engineering portion of this program.

During this report period, the first ten VTM packages (five of each type) were delivered to complete the December 14, 1962 delivery requirement. One Z-5364 VTM package was also delivered in partial fulfillment of the February 18, 1963 delivery requirement. The delivery of the remaining five packages required for this date will be on schedule.

Noise

The main problem with both VTM package types has been the noise performance. Three of the six Z-5364 VTM packages delivered did not meet the noise requirements; none of the five ZM-6001 VTM packages delivered met the noise requirements. Work during this report period resulted in some progress with respect to the noise performance of the Z-5364 package and in significant noise progress of the ZM-6001 package. Actually, the present noise requirements are easier to achieve with the ZM-6001 package than with the Z-5364 package. This situation is a reversal of that reported in the Second Quarterly Progress Report. Work during this interval to achieve improved noise performance is described under each package type.

G-E Developmental Type Z-5364 VTM Package

Saturation Current

Success in achieving increased saturation current was obtained with a control-ring redesign. This redesigned tube also incorporates a shortened filament (the height (h) was decreased from 0.075 inch to 0.050 inch above the filament ceramic as shown in Figure 1) to improve the vibration performance because the 0.075-inch height filament was marginal on vibration. The redesigned tube resulted in a delivered package which was excellent on noise performance; the original requirements were met. The disadvantage of this design, however, is that life expectancy is too short. Filament characteristic curves showed that the anode current was not stable with filament temperature. The delivered package data also showed that the emission and warm-up requirements were not met, giving further indication that the shortened filament design was marginal. It is felt that the problem is due to the shorter filament length resulting in greater heat loss to the filament ceramic, causing a greater than normal temperature gradient along the filament turns. If this is the case, then it is quite possible that less turns than required are at the proper emitting temperature, causing an unstable condition. Vibration data on this package with the shortened three-turn filament was not met due to an unexpected FM of four megacycles in the longitudinal plane. This anomaly is discussed in the section entitled "Vibration."

Specification Requirements

During this report period, Mr. J. J. Witte, of the Diamond Ordnance Fuze Laboratories, telephoned an advance notice of several specification changes, indicating a relief of the life, noise and vibration requirements. The modified life requirement is 40 hours minimum at 90 per cent of initial power output instead of the original 100 hours. The noise requirement change is 80 DBM over $\pm$25 volts modulation and a range of anode current from 18 to 22 milliamperes; the original noise requirement was 86 DBM over $\pm$35 volts modulation and a range of anode current from 16 to 24 milliamperes. The modified vibration requirement is 10 g with four megacycles maximum FM instead of the original 15 g and two megacycles maximum FM.

Due to these changes, it was felt that the optimum design would be a tube incorporating a 3-1/2 turn filament, 0.075 inch

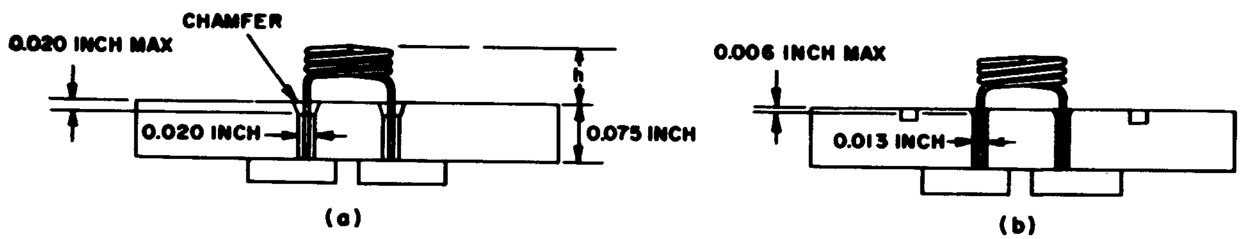

Figure 1 - Filament Assembly Designs

above the filament ceramic, and a scaled-up control ring of the best low-noise design. Expected results should be close to meeting the original life and noise requirements while meeting the latest vibration requirements. The filament with the 0.075-inch height was chosen to give a stable emitter instead of that observed with the 0.050-inch height filament. Previous vibration data showed that the 3-1/2 turn filament with the 0.075-inch height was within the modified vibration requirements, therefore, it was selected for optimizing life. Earlier work indicated a life in excess of 100 hours with this emitter. The control-electrode design was chosen for the saturation current and the best noise performance, therefore, it was scaled from that used in the best noise performance tube. Actually, the vibration performance is expected to be improved over the initial results because of the work performed on the filament assembly, which is discussed in the section entitled "Vibration."

Preliminary tests of these latest tubes indicate noise performance which meets the latest requirement but is marginal. Since this performance was not as good as expected, the X ray of the best low-noise tube was studied for differences with the present design. It appears that the control electrode-to-anode spacing of the best low-noise tube is greater than that of the present tubes. Several tubes with this modification will be assembled and tested for noise. At least one life-test package will be built and operated during the next interval.

Vibration results will be obtained when the packages for the February delivery are placed on final tests.

All packages for the February shipment contain tubes with 3-1/2 turn filaments, 0.075 inch above the filament ceramic, and the scaled-up control ring.

Noise

As previously stated, noise has been the chief problem with both packages, more so with the ZM-6001 VTM package. Actually, the tube parts used in the ZM-6001 VTM package are identical in every respect with those used in the Z-5364 VTM package, except for the number of anode vanes. Also, the same care in alignment is taken during tube assembly. It would appear that these identical tubes, except for the number of anode vanes, would be comparable on noise performance. Since it was not evident why the identical tube design, except for the number of anode vanes, was much better on noise in the Z-5364 package (twelve-vane tube) than in the ZM-6001 package (ten-vane tube), the ten-vane tube was tested in the Z-5364 circuit. Data showed a marked noise improvement, about 20 decibels better, over that recorded in the ZM-6001 circuit. Not only is the noise performance better, but the tube is less noisy over very wide ranges of anode current. In fact, the ten-vane tube is better with respect to noise in the Z-5364 package than the twelve-vane tube which had been used since the DOFL program. Based on this performance, the tube should not be considered noisy by itself, since its application is the prime consideration. Tube alignment, etc., appears to be secondary in achieving the best low-noise design. The disadvantage in this case is that the ten-vane tube is less efficient, approximately 20 per cent instead of the 30 per cent obtained with the twelve-vane tube. The lower efficiency is to be expected because decreasing the number of vanes requires tube operation at a lower magnetic field for the same anode voltage, since

$$V \propto \frac{B}{N}$$

where V is the anode voltage,
B is the magnetic field, and
N is the total number of vanes.

The efficiency is given as

$$\eta = 1 - \frac{V}{V_C}$$

where

$$V_C \propto B^2$$

and η is the efficiency,
V is the anode voltage, and
V_C is the Hull cutoff voltage.

This performance was discussed in a telephone conversation with Mr. J. J. Witte. As a result of this conversation, one package for the February delivery will be built and evaluated using the ten-vane tube. It may be that improved noise performance will be sacrificed for better efficiency even though this lower efficiency is comparable with the DOFL packages.

Vibration

Prior to this report period, vibration data gave inconsistent results. With the assumption that filament resonance caused maximum FM, attempts have been made to increase filament resonance beyond the maximum vibration frequency of 2000 CPS by the following two means: (1) decreasing the cantilever effect by decreasing the height (h) of the filament above the ceramic (see Figure 1) and (2) decreasing the mass by using a three-turn filament instead of the 3-1/2 turn filament used initially on this program.

The anomalies noted during tests of these filaments are as follows:

a) decreasing the height of the 3-1/2 turn filament from 0.075 inch to 0.050 inch in several tests resulted in FM which was greater than that recorded with the 0.075-inch height 3-1/2 turn filament. In some cases, the resonant frequency appeared to be lower with the shortened filament.

b) the same effects were noted on some tests with the three-turn filament; i.e., in some cases a shortened three-turn filament resulted in increased FM at a lower resonant frequency.

The one consistent result was that in all cases the resonant frequency of the three-turn filament was higher than that of the 3-1/2 turn filament.

As a result of these anomalies, it was felt that the problem was in the brazing of the filament to the filament ceramic (Figure 1). Inspection of the filament assemblies showed that the flow of braze material to the filament legs was random. Some assemblies had very little flow, others showed flow to the chamfer on one leg and little flow on the other. Since the filament ceramic is 0.075-inch thick, it is quite possible that the vibration anomaly is due to filament assemblies, where even though the filament height is decreased by 0.025 inch, the unsupported length inside the ceramic exceeded 0.045 inch resulting in worse vibration characteristics, i.e., decreased resonant frequency, and increased FM. For instance, if the flow of braze material is only 0.035 inch in the ceramic using a 0.050-inch height filament, this would correspond to a 0.075-inch filament which was brazed to the chamfer. In each case, the unsupported length would be 0.095 inch. All filament assemblies are now being inspected and only those in which the braze is to the chamfer are being used. Work was done to enhance this flow by modifying the amount of braze material used and the brazing schedule. As a result of this work, a yield of about 80 per cent good assemblies is presently obtained.

The eventual design of the filament assembly is shown in Figure 1b. The groove in the ceramic is the means for eliminating the effect of film build-up between the filament and the control electrode. In this design, the chamfer is reduced to a maximum of 0.006 inch from the original 0.020 inch to further decrease the cantilever effect and increase the resonant frequency. Also, the diameter of the two holes in the ceramic is reduced to 0.013 inch maximum from the previous 0.020 inch maximum. This change is made to increase capillary action and improve the yield. It has been noticed that, when the filaments are placed very near the center of the hole in the ceramic, the flow of braze material is least. In some cases when the filament is located close to one side of the ceramic, the material will flow up this side along the leg to the chamfer but not on the other side of the filament.

Results of the first efforts on this work, i.e., selecting properly brazed filament ceramics, will be obtained when the packages for the February delivery undergo final test. All filament assemblies used in these tubes were inspected for proper brazes.

Diamond Ordnance Fuze Laboratories' VTM Package (No. 48)

Diamond Ordnance Fuze Laboratories' VTM package (No. 48), which was sent to the General Electric Power Tube Department for correlation of data, was tested during this period. Comparison of its electrical performance with present tubes, shows that the present tubes are better with respect to film, efficiency, linearity, control current, and capacitance. The noise performance of the DOFL package was better than several of the delivered packages but not as good as the best low-noise version which was delivered. At the time of test, it was surprising that the vibration requirements were not met in any of the three mutually perpendicular planes with the DOFL package which used a three-turn filament.

G-E Developmental Type ZM-6001 VTM Package Redesign

Cavity

During one of Mr. Witte's visits to the General Electric Power Tube Department, it was decided that a higher center frequency (increased by about 150 megacycles) would be suitable. This change is in the right direction for reasons listed below.

1) Since $f \propto \frac{V}{B}$, an increase in frequency allows for increased anode voltage (V) for the same magnetic field (B). In reality, the magnetic field is indeed limited by the size and weight considerations of the magnet which limits the anode voltage for a fixed frequency. Increased anode voltage should result in increased power output, which is desirable, and increased saturation current.

2) Since it has been noted that increasing saturation current results in better noise performance, this is another expected advantage.

3) Increasing the center frequency allows a smaller cavity size. In this package, the smaller cavity size is advantageous because of the limited space available with the larger cavity size required at the lower initial center frequency. The original package design is cramped and requires skill in assembly.

One package with the redesigned cavity has been delivered. Power output and saturation current were increased somewhat, however, no noticeable noise improvement was observed at the increased power level.

Noise

During this report period, Mr. Witte indicated that this design would be more useful at higher anode voltages, up to 1000 volts maximum, as in the Z-5364 design. This information resulted in a significant improvement in the package performance with the use of four-vane anodes instead of the five-vane anodes used initially. The maximum anode voltage, which could be obtained with the five-vane anodes, the present magnet, and the increased center frequency, was below 800 volts. Rather than completely redesign the tube, it was decided to build several tubes with four-vane anodes, otherwise use all identical (existing)tube parts. A simple calculation shows that a 25 per cent increase in anode voltage could be expected by using an eight-vane tube (four-vane anode) instead of the ten-vane tube (five-vane anode).

$$V \propto \frac{B}{N}$$

Since B is constant; VN = constant

$$\text{or} \quad V_1 N_1 = V_2 N_2$$

$$(\sim 800)(10) = V_2 (8)$$

$$V_2 \approx 1000 \text{ volts.}$$

Electrical tests show that the noise requirements are finally obtained with this design. Actually, saturation current and maximum power output obtainable is now approaching the Z-5364 design.

Mr. J. Witte indicated a preference of increased power output over better noise performance. At his request, noise alignment will be made at the 75-DBM level. At this noise level, the power output is expected to be at least four watts (double the initial bogey requirement) at about 17 milliamperes of anode current. Two packages for the February delivery are being built with eight-vane tubes. The third required package incorporates a ten-vane tube since it had been started through before the eight-vane tubes were tested.

In attempts to further improve this package performance, eight-vane tubes with increased inside diameter of the anodes and six-vane tubes will be tested. Both of these changes are in the direction of achieving increased power output and higher saturation current. Upon completion of these tests, a decision will be made on the final tube design. Future tube work will have to await this decision. It may be that small changes to this final design will dictate the direction for further refinements. Two of the ZM-6001 VTM packages delivered exhibited slight spectrum breaks. The eight-vane tube does not exhibit this effect and is much easier to align in the magnet.

Though the eight-vane tube is less efficient than the ten-vane tube in this application (for the same reasons listed previously in the Z-5364 discussion of the ten-vane tube versus the twelve-vane tube), its efficiency is comparable to the twelve-vane tube in the Z-5364, about 30 per cent.

Capacitance

Data on the five packages delivered shows that a requirement of 60 picofarads can be met instead of the present specification of 50 picofarads. The capacitance of the Z-5364 has been reduced to less than 40 picofarads by eliminating the strip lines. This same scheme cannot be used in the ZM-6001 because of excessive RF radiation. Data on the DOFL package (Z-5364 type) showed a capacitance greater than 50 picofarads.

G-E Developmental Type ZM-6079 Voltage-Tunable Magnetron

Fixture modifications and seal-design changes, which were made during this interval, have improved the assembly yields of the ZM-6079 VTM. Detailed results of the various hydrogen-brazed assemblies are given below.

Filament Assembly

Fifteen filament assemblies were brazed during this report period. Two of these assemblies were lost because of fixture problems. Three Monel button assemblies developed leaks. Five of the six molybdenum button assemblies developed leaks. The molybdenum seals appear to be marginal with about one-half of the buttons developing leaks. These leaks are often not detected in the filament assembly but are observed after subsequent brazing operations. A 0.010-inch thick copper washer was placed between the ceramic and the Monel buttons on four additional assemblies to relieve the stresses causing these leaks. All four of these assemblies were acceptable, and Monel was chosen because of its better weldability. Fixture improvements have been made so that reliable seals can be made on an experimental basis. Additional fixture modifications will be required if factory production becomes feasible.

Anode Assembly

Ten anode assemblies were brazed during this interval. One of these assemblies was lost because of overbrazing and one other assembly because of a material defect. The other eight assemblies were acceptable. This assembly appears to be reliable and the present type of fixtures is very good.

Control Electrode Braze

Ten control electrode brazes were made during this period. Two assemblies were lost because of broken filaments during handling. Six assemblies were acceptable and two developed leaks for unknown reasons. It is possible that the assemblies with leaks were caused by using control electrodes which were not flat. These copper parts should be annealed and flattened in a special fixture prior of assembly. This is also true of the copper anode parts.

Cathode Braze

Eight assemblies were made during this interval. Six assemblies were acceptable and two had cracked ceramics. Molybdenum or Monel cathodes will crack the cathode ceramic unless a 0.010-inch thick copper washer is used as in the filament assembly. One of the above failures was in an assembly using the copper washer; it appears that if overbrazing occurs, the stress relief may be lost due to the copper washer going into solution.

Final Braze

Of the six good tubes mentioned above, three of the tubes were found to have leaks caused by the early filament button problem. One tube was exhausted in the vacuum bell jar, and a final braze of titanium to the molybdenum cathode with a silver-copper alloy was performed. This tube developed a leak and the source of the leak was not located. At this point, it was decided to adapt a tubulated cathode design thereby eliminating the final braze and facilitating easier leak-checking. The tubulated design, in use on other tube types, consists of a copper tubulation brazed with 65 weight per cent copper-35 weight per cent gold to the cathode prior to the body assembly. Two tubes were made using this method, and these tubes were exhausted successfully.

Electrical Performance

Very encouraging results were obtained from the two completed tubes. The first tube was life tested, and end of life was 55 hours which is comparable to vacuum-brazed tubes using the three-turn filament. Noise also appears comparable to vacuum-brazed tubes. These two items, namely, noise and life, were the key questions to be answered when this work had started. An additional advantage from this work may be the elimination of the film problem which has never been completely eliminated with the vacuum-braze techniques. Both hydrogen-brazed tubes exhibited no detectable film of the completed assemblies. The second tube which was to be packaged and life tested developed a leak during the packaging operation. This tube will be leak-checked to determine where the leak had occurred. It appears that the chief problem at this time is achieving good yields of subassemblies and completed tubes.

More electrical tests are required before a final judgment can be made on hydrogen brazing. Several completed packages will be tested during the next period after which life tests will be performed.

G-E Developmental Type ZM-6080 Voltage-Tunable Magnetron

The test cavity for this design has been completed and two tubes are available for testing. Coupling loops are being made after which electrical testing will begin.

MANUFACTURING

During this report period, the investigation for determining the effects of the electrical-discharge machining process on VTM anodes was concluded. A number of sample anodes, machined by the electrical-discharge machining method with a graphite tool electrode, were procured and processed. These samples were split into four lots, each of which underwent a different total process before being subjected to analysis on a mass spectrometer.

Sample No. 1 was merely cleaned by the most recently-developed chemical cleaning technique before analysis. Sample No. 2 was cleaned by this same technique and then vacuum fired in an Engineering Development Shop vacuum firing set according to their prescribed schedule; it was then tested. Sample No. 3 was cleaned in the same manner as samples No. 1 and No. 2 and then fired in the Manufacturing Unit according to the factory firing schedule, which consists of firing in an atmosphere of wet hydrogen and then vacuum firing. Sample No. 4 was analyzed after having been cleaned and only wet-hydrogen fired.

The types and relative amounts of impurities found during the subsequent analyses for each sample concerned are listed below:

Sample No.	Type and Amount of Impurity $\left(\frac{\text{grams} \times 10^{-8} \text{ of impurity}}{\text{gram of copper sample}}\right)$				
	Hydrogen (H_2)	Methane (CH_4)	Water (H_2O)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)
1	17.2	0.104	40.3	40.1	27.9
2	0.145	0.112	3.57	12.0	20.2
3	0.031	0.049	--	9.02	18.9
4	0.257	--	2.28	35.5	72.5

From these results, there seems to be little difference between samples No. 2 and No. 3, although No. 3 is slightly cleaner. This would seem to indicate that firing in wet hydrogen before vacuum firing would be a slight advantage. Wet-hydrogen firing alone, as indicated by sample No. 4, does reduce the impurity level in all cases except carbon dioxide, and this higher level is apparently easily reduced by subsequent vacuum firing.

The foregoing results seem to indicate that both the cleaning procedure and vacuum-firing procedure, as presently executed, are efficient and, so far as no tube operation problems are traceable to them, are adequate. The specific investigation work in this area will be reduced to an "awareness of" state unless or until future considerations deem it necessary to reopen the study.

Many of the fixtures needed to complete the assembly of the VTM package are being designed. Work on these designs was initiated during the latter portion of this report period and will be continued until all designs practical at this time have been completed. Since many of the package parts for the low-band tube have not yet been finalized, fixtures for these have been held up.

The design of fixtures for assemblies which are relatively firm to date is presently in progress. These include the RF-attenuator assembly fixture, the lead-assembly fixture, and a fixture for the high-band loop and connector assembly.

A magnet-alignment fixture has been designed around the "E" type test magnet to be used at the initial-test station. The five positions that are to be adjusted are all referenced to the magnet, allowing the RF test circuits and components to be rigidly fixed onto a reference plane while only the magnet is positioned.

The design of the magnet-alignment fixture, which will be used with the bowl-type magnet at the alignment-test station, will be started during the early portion of the next interval. Other items scheduled to begin during the next quarter are the bowl-magnet magnetizing fixture, the low-band test cavity, and the low-band loop and connector assembly fixture. A test cavity for the high-band tube was also designed during this report period and provisions were built-in to rigidly hold the cavity to the initial-test alignment fixture.

Some special test and processing equipment has been completed with Power Tube Department funds. These are specifically, a film and high-altitude test set and an aging rack. Although there is as yet no high-altitude specification to be met on this contract, this set can be used to check for film build-up within the vacuum envelope as well as check the quality of the potting compound and technique. The aging rack has the facility to simultaneously age ten tubes, of the same or mixed types, with independently set filament currents and to run emission tests on any of the ten via a switching arrangement. As presently designed, this aging rack can process tubes on this contract as well as other types produced on other contracts.

Fixtures needed to produce the VTM vacuum envelope have not as yet begun. This area will remain dormant until a firm tube envelope is decided upon.

A filament cutting fixture has been designed and built, and is currently awaiting modification of its nesting feature pending a firm filament design.

In an attempt to reduce the number of fabrication operations and hours required for fabrication, as well as to simplify the assembly techniques required in packaging thereby reducing unit cost, an investigation was initiated during this report period to evaluate die-cast cavity designs for both tube types.

A design for a die-cast, high-band cavity has been completed, and four of these cavities are presently being machined; two of aluminum and two of brass. The lower weight of the aluminum cavity is desirable, but a question of whether or not reliable tin plating to the aluminum can be accomplished consistently is a matter for consideration. The speed at which aluminum oxidizes may cause poor bonding of the tin plate to the aluminum and hence a poor bond of the tube to the cavity. For this reason, brass cavities will also be evaluated since a good plating job can be had on brass.

Although brass is approximately three times heavier than aluminum, the small relative size of the high-band cavity would not appreciably increase the weight of the whole package. The added weight of brass in the low-band package, due to the larger cavity size, may be a problem. A design for a die-cast, low-band cavity has not as yet been initiated due to modifications presently being evaluated in the low-band circuit. As soon as practical, this design will begin.

The major portion of the test equipment ordered on the facilities contract (DA-36-039-SC-22639) has arrived; three units remain to be delivered. As the equipment arrived, government property tags were assigned and the equipment was put into immediate use in the Engineering facility. The noise-test set and the linearity-test set have been built, and these are also being used in Engineering. Two RF shielded rooms were bought with Power Tube Department funds, and these have been installed in the Manufacturing area. Lighting has been installed and air-conditioning units are presently awaiting installation. As soon as this work has been completed and outlet strips supplied, the test cages will be ready for the installation of the test equipment.

QUALITY CONTROL

Allparts and assembly drawings that are finalized have been reviewed and characteristics classified.

Approximately 90 tubes have been measured for concentricity and parts spacing in the body-assembly state. These assemblies indicate good concentricities that are the result of well-designed assembly and brazing fixtures. Insufficient electrical test data was available during this period for comparison of dimensions with electrical performance.

Operator check instructions have been prepared for several tube-assembly operations. These instructions are planned to be a part of the quality-control manual.

CONCLUSIONS

ENGINEERING

1) A redesign of the tube used in the Z-5364 VTM package has resulted in excellent noise performance; however, poor filament characteristics dictated a redesign. Unfortunately, this redesign does not perform as well as expected with respect to noise.

2) The ten-vane tube is better on noise in the Z-5364 application than the twelve-vane tube. The price for this advantage is less efficiency.

3) An eight-vane tube resulted in much improved over-all performance of the ZM-6001 VTM package.

4) Preliminary electrical results indicate that the hydrogen-brazed version of the ZM-6079 is comparable to vacuum brazing.

5) Comparison of the electrical performance of present Z-5364 VTM packages with Diamond Ordnance Fuze Laboratories' VTM package No. 48 shows better performance for the present package in a number of respects.

6) Properly brazed filament assemblies should result in better and more consistent vibration data.

MANUFACTURING

1) Investigation of the electrical-discharge machined anode processing has been concluded.

2) Die-cast cavities should result in improving production capability for both package types.

QUALITY CONTROL

1) Measurements indicating good concentricity and parts spacing of the basic tube subassemblies show that the assembly and brazing fixtures are well-designed.

PROGRAM FOR NEXT INTERVAL

ENGINEERING

Several modified tubes will be tested for noise performance in the Z-5364 VTM package. Improvements will dictate work on the ZM-6001 VTM package.

At least one tube of each type will be packaged and life tested using the 3-1/2 turn filament. Several hydrogen-brazed ZM-6079 tubes will be packaged, tested to all electrical requirements, and life tested.

Electrical evaluation of the ZM-6080 will be completed.

Eleven VTM packages will be delivered according to the delivery requirements.

Vibration results of the February shipment will dictate whether further work is necessary in this area.

Attempts to finalize requirements for both package types will be made.

Six-vane tubes and eight-vane tubes with modified anode diameters will be tested in the ZM-6001 test cavity.

MANUFACTURING

The die-cast cavity evaluation will be completed.

The assembly fixture design will be continued.

The vacuum-envelope brazing fixture design will be initiated.

QUALITY CONTROL

Parts and raw-material inspection will be continued on in-house fabricated and purchased parts.

Additional operator check and inspection instructions will be prepared to complete the quality-control manual.

Fixture control on present fixtures will be continued and new fixtures added to the system.

Sufficient test data should be available to complete the tube dimension-electrical performance study.

PUBLICATIONS AND REPORTS

REPORTS

Monthly Narrative Report No. 7, Production Engineering Measure for Voltage-Tunable Magnetrons, by W. M. Piwnica, General Electric Power Tube Department, for the period from 18 October 1962 through 18 November 1962.

Monthly Narrative Report No. 8, Production Engineering Measure for Voltage-Tunable Magnetrons, by W. M. Piwnica, General Electric Power Tube Department, for the period from 18 November 1962 through 18 December 1962.

Monthly Narrative Report No. 9, Production Engineering Measure for Voltage-Tunable Magnetrons, by W. M. Piwnica, General Electric Power Tube Department, for the period from 18 December 1962 through 18 January 1963.

CONFERENCES

1. Organizations and personnel present:
   U.S. Army Electronics Materiel Agency
   S. A. Sokolove
   Diamond Ordnance Fuze Laboratories
   J. J. Witte
   General Electric Company, Power Tube Department
   D. J. Hodges
   W. M. Piwnica
   R. D. Pfeiffer

   Place and date:
   General Electric Power Tube Department, November 20, 1962.

   Subject:
   To review progress on program and to witness package testing prior to shipment.

2. Organizations and personnel present:

Diamond Ordnance Fuze Laboratories

J. J. Witte

R. Parkhurst

General Electric Company, Power Tube Department

D. J. Hodges

W. M. Piwnica

R. D. Pfeiffer

Place and date:

General Electric Power Tube Department, December 19 and 20, 1962.

Subject:

To review progress on program and to witness package testing prior to shipment.

IDENTIFICATION OF TECHNICIANS

During the period covered by this report, approximately 1103 engineering man-hours were devoted to this contract by the personnel listed below. A brief biographical sketch of Mr. R. D. Hanna appears in Appendix I.

P. M. Bogart	102 hours
R. D. Hanna	194
R. D. Pfeiffer	435
W. M. Piwnica	249
E. G. Soulier	123

Submitted by:

W. M. Piwnica

W. M. Piwnica, Program Coordinator
Voltage-Tunable Magnetron Engineering

Approved by:

D. J. Hodges

D. J. Hodges, Manager
Voltage-Tunable Magnetron Engineering
Power Tube Department

March 4, 1963

APPENDIX I - BIOGRAPHICAL SKETCH

Richard D. Hanna
Ceramist
Tube Technology

BS in Ceramic Engineering, New York State College of Ceramics at Alfred University (1953); General Electric Company Chem-Met program (1953); and numerous graduate courses in business management and inorganic chemistry. In 1954 he was assigned to the Power Tube Department for work on binder studies and ceramic body preparation for dry pressing. Also engaged in process control and trouble shooting of manufacturing problems related to ceramic-metal seals. In 1958, transferred to Aircraft Nuclear Propulsion Department where he was concerned with the sintering of beryllia and zirconia, mechanical and thermal properties of beryllia, and reactions between beryllia and other refractory materials. Returned to the Power Tube Department in 1960 where his duties have included the establishing of ceramic quality acceptance procedures, maintaining control of the production ceramic metalizing process and trouble shooting of manufacturing problems related to ceramic-metal seals.

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